A mechanism for tracking the water level

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Abstract. This research focuses on developing an advanced monitoring system for water levels in agricultural storage tanks, a critical component for ensuring reliable crop irrigation. In the context of increasing water scarcity and potential supply disruptions, enhanced monitoring of tank water levels becomes essential for sustainable farming practices. The proposed system addresses this need by providing farmers with precise, real-time data on water availability, enabling informed decision-making regarding irrigation scheduling and water resource allocation. The true innovation of this system lies in its ability to offer continuous visibility into tank water levels, empowering farmers to develop optimized water use strategies. By leveraging Internet of Things (IoT) technology through the Blynk application platform, the solution enables comprehensive tracking of both water levels and consumption patterns. The system incorporates threshold-based alert functionality to notify users when water reserves reach critically low levels. Experimental results demonstrate the successful implementation of this monitoring solution, with validation data confirming its accuracy in tracking water levels under various conditions. The Blynk interface has proven particularly effective in displaying real- time level information and generating timely alerts. This technological solution represents a significant step forward in agricultural water management, offering practical benefits for farmers operating in water- constrained environments.

1 Introduction

Accurate, affordable, and dependable level measurement technology is crucial in today's world to ensure the smooth operation and success of various systems. In industries like biochemistry, transportation, flood warning systems, and basic home water management, level measurement plays a key role. There are numerous types of level control, with overflow prevention to avoid exceeding a storage tank's maximum capacity and fully drain controls to prevent pumps from running dry being among the most common. Agricultural technology encompasses the instruments and machinery primarily or exclusively used to support farming operations. Examples include plows, threshers, and irrigation systems, many of which have a long history in agriculture and have undergone continuous reinvention and redesign. For instance, plows originally relied on animal power but are now typically motorized.

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Agricultural water sources are diverse, ranging from surface water like rivers, streams, and irrigation canals, to impounded water from ponds and lakes.

The primary goal of this project is to create a Water Level Monitoring System for contemporary agriculture, enabling the monitoring of water levels without the need to open the water tank. This system will be developed using an Arduino Nano to automatically display the water level on user devices via the Blynk app. Additionally, the project aims to assess the system's effectiveness in providing precise water level readings in the tank.

2 Methodology

In this section, we will discuss the planning framework that can be used to create a work plan for the topic at hand. It includes all the details about the sensors and components, ranging from the microcontroller to the type of Wi-Fi module. Additionally, we will explore the methods used to achieve the objectives of this project. The main focus of this chapter is on designing a water monitoring system powered by the Arduino Nano microcontroller. We will also discuss the application of IoT technology, which involves transmitting water level data from the water tank and displaying it on the user's device using the Blynk application.

Block diagram

This section will provide a detailed discussion on the project design, preparation of components, software application, and project flow. Fig.1 shows the block diagram of the project design, which is use Arduino Nano as a micro-controller and ESP8266 like a Wi-Fi module. The main purpose of this setup is to transfer data from the Ultrasonic sensor to the Blynk Application.

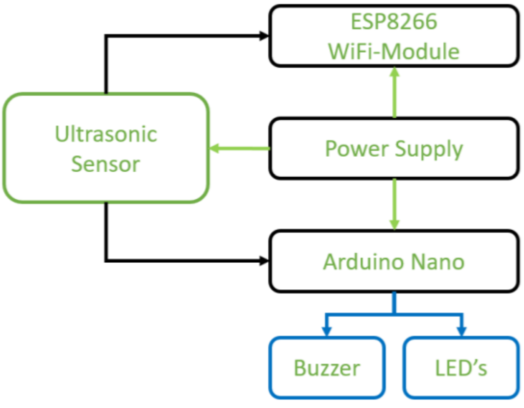


Fig.1 Project of the block diagram

In Fig.2 flowchart shows that the steps involved in the Water Level Monitoring System. The process starts from the Ultrasonic Sensor measuring the distance between the water surface and the sensor. Then this data is transmitted to the Arduino Nano, which calculates the water level by using a specific formula. If the water tank level should be low, both the buzzer and LED will be turned on immediately. Simultaneously, the information will be sent to the Wi-Fi module which is called NodeMCU (ESP 8266). Finally, the user's smartphone will receive all the information through the Blynk application.

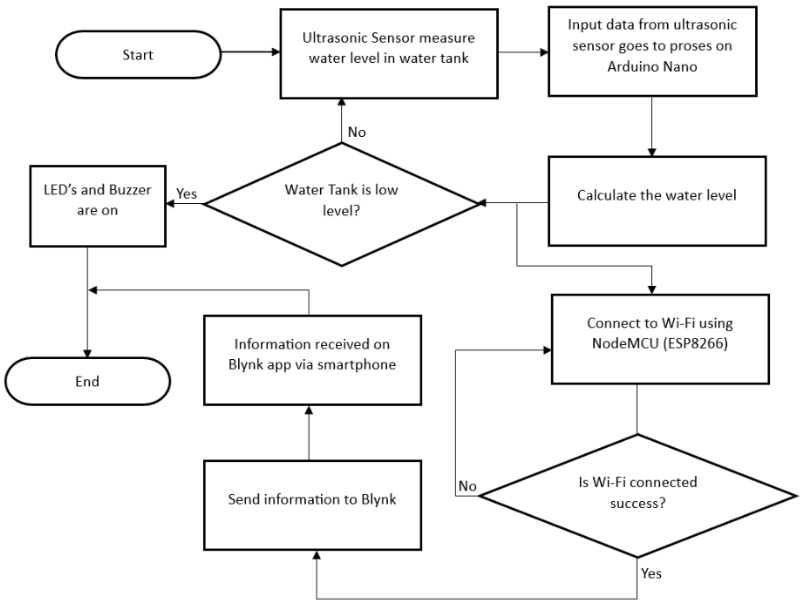


Fig.2 Flowchart Aquatic Elevation Tracking Mechanism

Development of hardware

To create the Water Level Monitoring System, we utilized several high-performance components that were cost-effective. These components were carefully selected to meet the objectives of the project and contribute to the development of an Internet of Things (IoT) platform for water level monitoring. Each part or component chosen has its own unique advantages [1-3] The unit of each component used in this project is presented in Table 1.

Table 1. Components

Name of component	Unit
Arduino Nano	1
Ultrasonic Sensor (HC-SR04)	1
NodeMCU (ESP8266)	1
Buzzer	1
Resistor 330 Om	5
LED	5
Voltage regulator 3.3 V (LD1117)	1

Development of software

The software used for this project includes the Arduino Software IDE for uploading the Arduino program to the Arduino board, as well as the Blynk IoT platform for monitoring real-time data on the Blynk application. Blynk allows users to create a digital dashboard and interface based on the project's function, and is compatible with microcontrollers like Node MCU ESP8266. The Blynk application has three main components: controlling and displaying data on widgets, a cloud service for communication between smartphones and projects, and libraries with widgets for sending sensor data to a mobile application.

Measurement of parameter

For this project, the software utilized consists of the Arduino Software IDE for uploading the Arduino program onto the Arduino board. Additionally, the Blynk IoT platform is employed to monitor real-time data through the Blynk application. Blynk enables users to create a digital dashboard and interface tailored to the project's purpose, and it is compatible with microcontrollers such as Node MCU ESP8266. The Blynk application comprises three primary elements: widget control and data display, a cloud service facilitating communication between smartphones and projects, and libraries featuring widgets for transmitting sensor data to a mobile application.

- height

The Actual Height can be determined as the distance between the ultrasonic sensor and the water level in the water tank. This Actual Height is represented mathematically as Eq.1.

$$h = R_{max} - D \tag{1}$$

- Volume of cylinder

The volume of a cylinder water tank is determined by its shape. The volume can be calculated using mathematical equation Eq.2.

$$V = \pi r^2 h \tag{2}$$

- To obtain water in liters

To convert the value from the volume of a cylindrical shape to liters, use the following formula. The volume in liters is represented by Eq.3.

$$L = V/1000 \tag{3}$$

- Percentage Error

In these studies, Eq.4 demonstrates the Percent Error equation used to analyze the error in the water level monitoring system. This equation involves measurements and manual calculations to determine the Percent Error.

$$\%\text{error} = \frac{|m - c|}{c} \times 100\% \tag{4}$$

Here,
h – Actual height
D – Distance
V – Volume of cylinder
π – Pi
r – Radius
L – Liters
m – Measured
c – Manual calculation

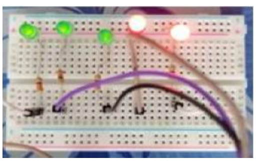
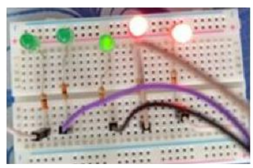
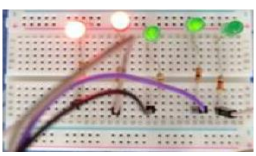
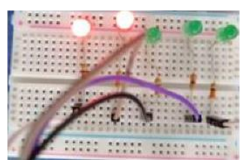
3 Results and Discussion

In this section, the experimental results and progress of the project development for the Water Level Monitoring System are analyzed. The methodology implemented in each phase of the project has led to the achievement of the desired outcomes. The hardware results show that the Water Level Monitoring System can operate smoothly at four different distance stages, with LED indicators and buzzers functioning properly. Additionally, the Blynk application is able to display the water level in the tank in real time, providing measurements in liters and sending notifications if the water level is low.

Results of hardware testing and Blynk application

The Blynk application is designed to display the water level in a water tank and provide real-time monitoring with measurements in liters. Additionally, the Water Level Monitoring system includes 5 LED indicators that display the water level. These LED indicators have two colors: green and red. The green LED indicates a good water level condition, while the red LED indicates a low water level condition. The behavior of the LED indicators is determined by four distance stages: distance ≤ 80, distance ≤ 60, distance ≤ 40, and distance ≤ 20. Table 2 provides a breakdown of the LED indicators and their corresponding stages for indicating the water level in the tank.

Table 2. The LED indicator has various stages.

LED Indicator	Blynk app	LED Indicator	Blynk app
			
			

Real-time monitoring and calculation produce the outcome.

The water level monitoring systems use ultrasonic measurement for accuracy in measuring tank water levels. The ultrasonic sensor is crucial for providing precise readings based on time-of-flight measurements. These sensors emit sound waves beyond human hearing range, with the transducer acting as a microphone to transmit and receive ultrasonic sound. Two experiments were conducted using a 1000L water tank: one to measure height and distance, and the other to monitor water levels for precision using data collected from the Blynk application.

The water level monitoring system in the first experiment needs to collect 50 readings of height or distance based on the height of the water tank. The maximum height of the water tank is 1000 liters with a radius of 53.2 cm. Fig.3 displays the user interface of the Blynk application monitoring the water level condition. The initial height measurement is 104.2 cm, decreasing to 26.0 cm. Data is collected from these height measurements to record the volume of water based on the current height. Table 3 displays recorded data with various heights and values from manual calculations. The percent error is calculated to compare real-time data with manual calculations using the formula implemented in the water level monitoring system.

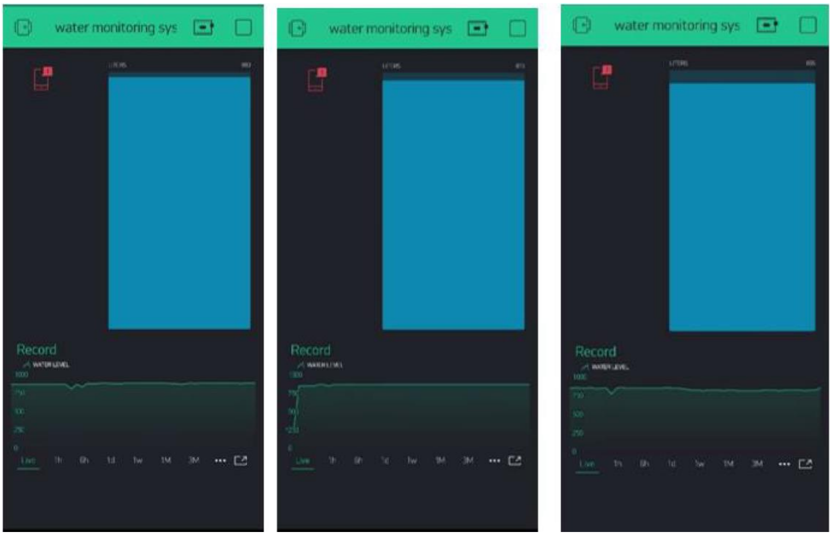


Fig.3. The user interface of the Blynk application

Table 3. Data from the water level monitoring system is collected.

№	Measurement (L)	Distance (cm)	Actual Height (cm)	Manual calculation (L)	%Error
1	926	0.8	104.20	926.02	0.02
2	890	4.86	100.14	889.94	0.06
3	882	5.75	99.25	882.03	0.03
47	61	98.14	6.86	60.96	0.04
48	44	100.05	4.95	43.99	0.01
49	35	101.06	3.94	35.01	0.01
50	26	102.07	2.93	26.04	0.04

The water level monitoring system produced fifty different measurements of heights and volumes of water. These measurements were obtained using formulas programmed into the controller, which can accurately measure the volume of water in liters in the tank. The controller has a maximum range of 105 cm. To measure the water level, the system utilizes ultrasonic sensors that measure the distance between the sensors and the water surface in the tank. This distance is then used to determine the actual height of the water level. Table 4 displays all the data from the experiment, including manual calculations and percent error.

Table 4. Data from the water level monitoring system is collected.

№	Measurement (L)	Distance (cm)	Actual Height (cm)	Manual calculation (L)	%Error
1	0	64.00	0.00	0.00	0.00
2	9	59.04	4.96	8.97	0.33
3	18	54.10	9.9	17.97	0.17
4	21	52.39	12.00	21.00	0.00

5	27	48.87	15.13	27.36	0.22
6	41	41.32	22.68	41.01	0.05
7	50	36.20	27.80	50.28	0.57
8	75	22.58	41.42	74.91	0.12
9	95	10.98	53.02	95.60	0.62
10	108	3.81	60.19	108.86	0.79

Based on the manual calculation of the water tank volume, there is only a slight difference in decimal points when compared to the real-time reading. This is because manual calculations are rounded to two decimal points, while the Blynk application displays whole numbers. If the decimal value is converted to a whole number, the result will match the display value on the Blynk application. For example, in Table 3, data number 1 shows a measurement value of 926 liters on the Blynk application and 926.02 liters in the manual calculation. When the manual calculation is rounded to a whole number, it matches the display value on the Blynk application.

To assess the accuracy of the water level monitoring system, we will use the percentage error formula in this experiment. For the first measurement value, the measured value is 926 liters, while the manual calculation yields 926.02 liters. The percentage error for this data is 0.02%. Overall, the percentage error for all the data is not more than 0.07%. The largest error recorded in the water level monitoring system is 0.06% for data number 37, while all other levels range from 0.01% to 0.05%.

In the second experiment, we tested the water level monitoring system to measure an actual water level and assess its accuracy in collecting data from the Blynk application. The system used the same source code but had a different specification for the water tank or storage. We collected 10 different data sets based on the water level in the storage. Each data set consisted of 5 readings that were recorded for the purpose of this study.

Table 5. The average of five readings from the Blynk application.

№	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Average
1.	0	0	-5	0	0	-1
2.	9	9	9	9	9	9
3.	18	18	18	18	18	18
4.	21	21	21	21	21	21
5.	27	27	27	27	27	27
6.	41	41	41	41	41	41
7.	50	50	50	50	50	50
8.	75	75	75	75	75	75
9.	95	94	95	95	94	94.6
10.	108	108	108	110	108	108.4

During this experiment, various data values were observed, resulting in different patterns of the LED indicator. For instance, when the water level monitoring sensor detects low water levels, two red LEDs and a buzzer are activated, and a warning notification is sent to the user's smartphone. Figure 4 displays the LED indicator and notification as seen on the Blynk application.

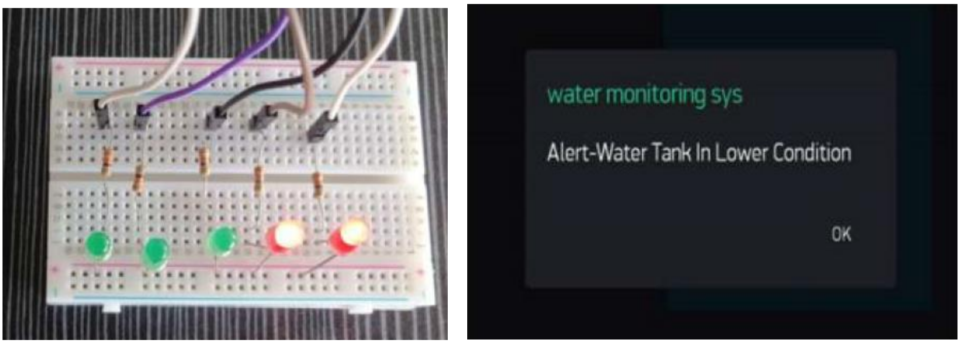


Fig.4. LED indicator and notifications from the Blynk application

In this section, the values obtained from the water level monitoring system are displayed. Each level will be measured five times and all the data will be recorded in a single table. Table 5 presents the complete dataset, which is used to analyze the values in the Blynk application. The average of the five readings taken and recorded is calculated for each value in order to conduct these studies.

During the experiment, five readings were taken and the average value of all the data was calculated. All the readings were consistent except for three instances. In the first data point, there was a difference in the third reading, which showed a value of -5L. In the ninth data point, the water level was 95L during the high condition, but during the second and fifth readings, it showed a value of 94L. Lastly, in the fourth reading during the high condition, the value displayed was 110L. Equation 4.5 was used to calculate the average value of all the data. Only three data points were affected by having different readings compared to the other five readings. The average values for data points one, nine, and ten were 1L, 94L, and 108.4L respectively. These variations were caused by water waves in the water storage, which interrupted the readings of the ultrasonic sensor. However, this effect is minor and the water level monitoring system will provide accurate values on the Blynk application.

4 Conclusion

This project focuses on a Water Level Monitoring System powered by the Blynk application. The system provides information about the water level in a water tank through LED indicators, a buzzer, and the Blynk smartphone app. The monitoring system has been successfully developed to monitor water levels accurately. However, the analysis shows that there is some instability in the precision of the system, as indicated by percent error and average readings. To improve accuracy, further research can be done to explore different design options, such as using different level detection methods and displaying water volume in liters with two or three decimal places. This would enhance the system's ability to accurately measure water levels.

References

1. F. B. Nurmatova, D. S. J. Raphael, K. I. ugli Muradov, Digitalization and renewable energy advancements and opportunities. (2023)
2. M. Gan et al., An improved machine learning-based model to predict estuarine water levels. Ocean Modelling. pp. 102376 (2024)
3. Kh. Muradov, A. Djalilov, F. Nurmatova, S. Abdimavlanova, Interscience. **11-3(328).** 45-49 (2024)